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PSYCHICAL LIFE IN PROTOZOA.¹

By G. P. WATKINS, A. B.

Any one of the higher animals, it is commonly held by modern physiologists, is a colony of unicellular organisms. Hence the cell in its free and undifferentiated state should possess, in some elementary way, all the properties which are later highly developed through specialization in the metazoon. The following words of Verworn are perhaps representative of the present attitude of physiologists: "Elementary life phenomena are inherent in every cell, whether it be a cell from the tissues of higher animals, or from the tissues of lower animals, whether it be a cell of a plant, or, lastly, a free cell, an independent unicellular organism."² Among these properties of the original free cell must have been something corresponding to mentality. Mind has not been superadded in the course of animal evolution. As Cope says: "The conscious cell is the primitive cell, and the unconscious cell is the modified or specialized cell."³ The cells of the brain have been perfected with reference to psychical attributes, but, again in the words of Cope, they are "the least modified of all those that constitute the soma of the metazoon, and thus they resemble most nearly the simple beings which constitute the lowest forms of the Protozoa."⁴

From all this it should follow that a specialized nervous system or a high organization is *not* a precondition to mentality, but that mentality in some sense is a property of the original cell.

If the above theory be accepted, we have, in the evolution of the higher organisms, a compounding of minds. The human being is a colony psychologically as well as biologically. There are specialization and interdependence of diverse elements, and the unity is not the unity of a simple thing, but that of a system. Thought is an aggregate function.

Prof. James, however, objects that mental states cannot be compounded and cannot be composite. But this is only one aspect of a very general difficulty for him. For he says: "Atoms

¹ From the Psychological Seminary of Cornell University.

² *Monist*, art. "Modern Physiology," Vol. IV, p. 371.

³ *American Naturalist*, art. "Evolution of Mind," Vol. XXIV, p. 903.

⁴ *Ibid.*, 903.

of feeling cannot compose higher feelings *any more than atoms of matter can compose physical things*" (italics mine); and, also: "The thing we name has no existence out of our minds."¹ Thus is involved the question as to what is the nature of a compound in general. And it must be admitted that, from a philosophical point of view, though mental states have the form of time, and some of them that of space, one can know directly only a single mental state in isolation. In going beyond the mental state as such, there is a sort of inference. If several mental states connected in experience are jointly referred to various *attributes* of a particular *thing*, it is an inference. If, under certain conditions, some of these *things* disappear more or less completely, and we have in their place another *thing* with attributes more or less different, this we name a *compound*. This compound, it must be admitted, is such only with reference to its effects on us. But is anything else, so far as we know it, what it is, except with reference to its effects on us? As to what occurs apart from us, we can only infer, can only symbolize. But symbolize we must. It is our nature to construct a world-order by such inference. And among notions found of use in this process is that of a compound,—a something which, under certain circumstances, takes the place of, or results from the union of, several other things. We need not be able to recognize the elements in the compound; we never do in chemistry. We need not be able to picture to ourselves under the forms of space and time the mechanism of the process of compounding. We do not usually, and ought never to think of a compound as the mere sum of its elements,—and this is the mistaken position against which Prof. James' argument is really directed. We recognize that a compound is itself and not something else. The sum of the matter is that the elements have been lost in the compound; in which they may seem to leave no traces.

A compound in this sense is just as conceivable, applied to mental states, as it is for chemical elements. There is no "assumption that our mental states are composite in structure, made up of smaller states conjoined" (italics mine), as Prof. James says there is.² "Resemblance," it is admitted, "cannot always be held to involve partial identity."³ But partial identity with elements is no essential feature of a compound; and, furthermore, the statement is too weak, "cannot always" implying "can sometimes." "If one feeling feels like no one of the thousand" of which it is composed, it nevertheless can "be said to be the thousand"⁴ in the same sense that water

¹ *Principles of Psychology*, Vol. I, p. 161.

² *Op. cit.*, I, 145.

³ *Ibid.*, 158, ftn.

⁴ *Ibid.*, 163.

may be said to be composed of hydrogen and oxygen. According to the usage of language a thing *is* its elements related or conditioned in a particular specified way, or *is composed* of such and such elements, simply enumerated. Nobody maintains that a compound is its elements under no matter what conditions; but only that it contains them. If the "mind-stuffists and associationists" say "that if the states be posited severally [under certain conditions, let us add] their collective consciousness is *eo ipso* given; and that we need no farther explanation or 'evidence of the fact,'"¹ they are doing no more than the chemists who say that, given free hydrogen and oxygen gas under certain conditions of position and the advent of something hot enough, and you have water. It is wholly a question of factual connection in experience, beyond which we cannot go. Nobody says unqualifiedly that the series of states is the awareness of itself,² but rather that the series under certain circumstances carries with it awareness of itself. The latter may be "evolved"³ out of the former in the same sense that anything is evolved out of other things. Composition is not the mere summation or mixing or juxtaposition which Prof. James, with resulting irrelevancy, assumes it is.

Let it be admitted that compounding consists only in a merging or losing of one set of effects to form a new set, and that an aggregate unity exists for the subject only.⁴ All the identity we can allege is the inferential identity of substance or support,—something beyond our experience. But mental states can be compounded in the same sense that any other things can be, and the concept of psychical as well as of physical compounds is found to be useful. Whether the "soul" is that upon which these effects combine is another question. Prof. James does not quite dare to go so far as to maintain that the "unitary" character of mind demands that all impressions be concentrated at a single point or a single cell of the brain, yet his leaning towards a theory of a central or "pontifical cell"⁵ strongly reminds one of Descartes. But nothing is explained by going to the substance behind mental states, whether the name given be soul or something less objectionable. Science has no use for such an hypothesis. We do not even know what "unity" means, as predicated of this substance. Hence we can accept compounding as a phenomenal fact in the one sphere as well as in the other.

To be taken in connection with the position of Prof. James

¹ *Ibid.*, 162.

² *Cf. ibid.*, 162.

³ *Cf. ibid.*, 160.

⁴ Royce in James, *op. cit.*, I, 159.

⁵ *Ibid.*, 179-81.

just touched upon is his attitude towards the relation between the mental and the physical. He thinks it "the ultimate of ultimate problems . . . why and how such disparate things [as thought and brain] are connected at all."¹ This "why and how" means for Prof. James, I suppose, as for many, reducing the connection of thought and brain to figuration in the spatial mode of perception. The difficulty is that we cannot picture in this way a mental state, nor can we thus represent its connection with a thing that we can picture, *i. e.*, an extended object. The relation cannot be thought of mechanically, in terms of space. But the factual connection remains the same, and it is with this that we are concerned. Color and form are "disparate," but they are both perceived in the space mode. Is this the essential thing rather than the fact of connection?

There are difficulties, too, in any other than the "mind-stuff" or composite interpretation. It is quite possible to accede to the implication of Prof. James' challenge, "If evolution is to work smoothly, consciousness must have been present at the very origin of things."² It is perhaps better, however, from a methodological point of view, for us, as psychologists, to contemplate the possibility of carrying back mind only so far as we find life. Here the principle of continuity may help us; but the question is one of the interpretation of evidence. Prof. James, however, is not so good an evolutionist.

What, for instance, are we to do with secondary reflexes? Prof. James says: "Either lack of memory or split off cortical consciousness will certainly account for all of the facts."³ This is, indeed, taking liberties with memory. It is just when one is intently occupied with some train of thought that one is most likely to respond to stimulus reflexly; and at this time anything crossing consciousness to interrupt this train (for "we cannot have two feelings in the mind at once")⁴ would be especially likely to be remembered. As for the "split-off cortical consciousness," it is quite in accord with the theory that James opposes, but may an individual have several *unitary* "souls" or minds? So, it seems, the real difficulty of pointing out where this "disparate" element, consciousness, enters in, both in the development of the individual and in the animal series,⁵ is far greater than any imagined metaphysical

¹ *Ibid.*, 177.

² *Ibid.*, 149.

³ *Ibid.*, 165.

⁴ *Ibid.*, 157.

⁵ Pres. Jordan has an article on the "Evolution of Mind," in Appleton's Pop. Sci. Mon. for Feb., 1898, also reprinted in "Footnotes to Evolution." The article has great *popular* value because of its attitude towards continuity, but it is quite inadequate psychologically, as it assumes, without hint of possible difficulty, that consciousness evolves from reflexes.

difficulty about the intelligibility and conceivability of compounds, both physical and psychical. Acquired reflexes show that there is no chasm between conscious and unconscious action.

Continuity, too, unless the survival value of consciousness is done away with, is necessary for the explanation of instincts. One view would make complex reflexes and instinctive actions mental degenerates. Another would evolve mind from reflexes. But where is the limit to such mechanical or reflex and instinctive adaptation? When would the uncertainty introduced with consciousness be an advantage to the organism? Logically, the second view makes consciousness an epiphenomenon, man an automaton, and his mind no part of the mechanism. Furthermore, on the supposition of "disparateness" in reality as well as in fact, consciousness could hardly be other than an epiphenomenon correlated with a certain complexity of nervous organization. But the relation is not satisfactory. Why should there be such a correlation? And where would be the line between conscious beings and the unconscious? Our knowledge of reflexes, inherited and acquired, does not lessen the difficulty. These facts point to some theory according to which consciousness would be correlated with hesitation, indecisiveness, and imperfection in the ordering of reaction, rather than with complexity. It is difficult to see how such an incipient consciousness at the stage of complicated reflexes could be other than disastrous. Adaptation of species could, *ex hypothesi*, be perfectly kept up by mechanico-organic variations. Incipient consciousness in the individual organism would be disadvantageous because of loss in rapidity and accuracy of reaction. The little adaptability to change in environment would probably be not sufficient to outweigh this disadvantage, and even that little would be but a duplication of means to an end already attained by purely physical or organic variation in the species. And, since the physical can do this adapting, if it can do so much besides in the way of complex reaction, why should there be any mental at all? What opportunity is there for it even to come on the field?

A primitive consciousness, on the other hand, may have been of survival value. It would have had to compete only with the simplest, even merely chemical, forms of reaction. Its incipient complication of modes of action would probably be of high adaptive value. It is not impossible that the great function of consciousness in the animal world is the building up of complex modes of reaction. The fixity of the reflex is perhaps a later stage in which mind is largely relieved of the care of completed modes of reaction. In the development of species consciousness may thus in some cases have even been quite lost by adapta-

tion. With consciousness accompanying life at the start, indefinite variation in the mental as well as in other matters organic should be expected, so that mind would be moulded by its environment into forms of survival value. Not only could conscious adaptation, through the inherited effects of habit, aid in the formation of instincts and reflexes, but it has perhaps also done more than we suspect in developing the potentialities of organized matter.

Although it has not been necessary, for present purposes, to distinguish between two separable problems involved in this discussion, it may be well here to touch upon the bearings of a possible distinction. Prof. James attacks indiscriminately "mind-stuffists and associationists." But the problem of the compounding of minds is different from that of the compounding of sensations, and the difference is not wholly that between the subjective and the objective points of view, since the minds compounded would scarcely be thought of as becoming each a particular sensation in the resulting mind. What seems to be the best attitude toward the problem of the compounding of sensations has already been indicated. As for the compounding of *minds*, it seems to the writer that the question is one of fact, and that the answer is implicitly taken for granted by modern psychology. No one finds a difficulty, either in the addition of "minds" or in the fact of co-operation, when, in the course of evolution, more cells than before come to perform the mental function. Nobody maintains that less than a plurality of cells function during, and by necessity coincidentally with, the consciousness of an individual.¹ The doctrine of psychophysical parallelism itself involves a multiplicity of cells functioning in unison, with activity not in a single point, but in an area of the cortex necessary for the conscious accompaniment. If it be still objected that we cannot *see how* this compounding of minds could take place, the difficulty is probably due only to what is in some sense an *idolon tribus*, our habitual mechanical mode of thinking.

Thus, it is hoped, have been removed any *à priori* difficulties in the way of admitting consciousness in the organic world wherever the facts seem best explained by supposing it present. There is no reason why we should admit consciousness only at the latest possible stage of evolution. We have to admit it as a *vera causa* somewhere. We should be ready, then, to admit it, always guarding against anthropomorphism, at whatever degree of complexity the evidence warrants. And we should also use it, with due regard for continuity, in a way to give the best

¹ But cf. the leaning in James' "pontifical cell," pp. 179-81.

theory of organic life as a whole, both physiological and psychological.

M. Binet has collected an interesting body of facts bearing on the habits of some micro-organisms, which, he seems to believe, have "psychical life." Yet in one place he says: "We are not in a position to determine whether these various acts are accompanied by consciousness, or whether they follow as simple physiological processes."¹ Furthermore, he does not discuss the interpretation of these facts, though, since most of the facts themselves seem to be accepted, this is really the critical point.

Have protozoa psychical life? This again involves the question: What is the objective criterion of mentality? And the answer to this must have reference to the essential nature of mind,—a question not to be settled by characterizing mind as having "consciousness," for this term means hardly more than mind in the concrete, perhaps with an implication of *self*-consciousness.

In predicating mind of some other being than myself, I am inferring the existence of something of which I can have no experience. My direct knowledge is limited to my own consciousness. Inferring the presence of mind in others, I proceed by analogy and by comparison with my own acts objectively considered. Resemblance to me in respect of possessing consciousness is inferred (so far as I arrive at the conviction rationally) from resemblance in other respects. Therefore the cogency of evidence diminishes as I recede from minds like my own.² Yet there must always be some quality in common with my own mind,—the quality, too, if the word 'mind' as thus used is to be susceptible of definition at all, upon which that definition depends.

On the criterion of mentality, Romanes' position is perhaps the most important, and as nearly typical of current views as any. He says: "Ejectively considered, the distinctive element of mind is consciousness, the test of consciousness is the presence of choice, and the evidence of choice is the antecedent uncertainty between two or more alternatives."³ Still he thinks that complexity and unpredictability are not enough, but that we must know the non-mechanical character of the act or the mentality of the agency,⁴—which position is not very satisfactory, since these are just the things we should be uncertain about. Again, he says, "it does not follow that all adjustive

¹ *Psychic Life of Micro-Organisms* (trans.), Chicago, 1897, p. 61.

² So Romanes, *Mental Evolution in Animals*, p. 22.

³ *Mental Evolution in Animals*, p. 18.

⁴ *Ibid.*, 19.

action in which mind is concerned should be of an antecedently uncertain character;” but by independent evidence [independent of any particular case of antecedent uncertainty, presumably] we may know that the agent is mental,¹—which is a necessary precaution, since with greater knowledge of human nature and circumstances comes greater predictability of acts; but this does not reduce the province of mind. For Romanes all that is meant in the objective sense of mental adjustment is that it is “of a kind that has not been definitely fixed by heredity as the only adjustment possible in the given circumstances of stimulation.”² But “it is not practically possible to draw a definite line of demarcation between choosing and non-choosing agents.”³ The common sense distinction is valid, as in zoological classification.⁴ It is asked (significantly enough): “Does the organism learn to make new adjustments, or to modify old ones, in accordance with results of its own experience?”⁵ Heredity cannot have provided in advance for alterations in its own machinery.⁶ But there may not be enough mind for the learning to make new adjustments, or there may be defective memory, and some parts of our own nervous system not concerned in consciousness may learn by experience.⁷ The practical danger is in not seeing mind enough.⁸ The criterion is of “the upper limit of non-mental action, not of the lower limit of mental.”⁹

The above gives the view of Romanes on the criterion of mentality. The vagueness and inconsistency that strike the reader are not due to misrepresentation. Other psychologists and biologists, also, take positions similar in this as in other respects.

M. Binet accepts Romanes' criterion of choice,¹⁰ but seems not to know definitely how it is to be used, or what results it may give.¹¹ Prof. James says: “The pursuance of future ends and the choice of means for their attainment are thus the marks and criterion of the presence of mentality in a phenomenon;” the end is fixed while the pathway may be indefinitely modified.¹² The beginning for Cope is conscious memory, with the consequent possibility of more exact adaptation or design in an act.¹³ Rapid and transient response in direct answer to certain changes in the environment seems to be Prof. Lloyd Morgan's criterion of mentality.¹⁴ Wundt's view is this: “That the creature knows its proper food, and may be determined in its knowledge of it

¹ *Ibid.*, 18.

² *Ibid.*, 18.

³ *Ibid.*, 19.

⁴ *Ibid.*, 19.

⁵ *Ibid.*, 20.

⁶ *Ibid.*, 21.

⁷ *Ibid.*, 21.

⁸ *Ibid.*, 21.

⁹ *Ibid.*, 22.

¹⁰ *Op. cit.*, 109.

¹¹ *Ibid.*, *passim*.

¹² *Op. cit.*, I, 7-8.

¹³ *Loc. cit.*, 905.

¹⁴ *Animal Life and Intelligence*, p. 243.

by previous impressions, is regarded as the first and primal indication of the presence of animal, *i. e.*, mental life."¹ Memory, he believes, is presupposed in cognition, and the presence of cognition is the point to be proved.

Most of these positions are to be criticised for admitting more or less of the subjective, and none are perfectly definite and satisfactory. Purpose and choice, moreover, taken directly as evidence of the workings of mind in the animal world may, since Darwin, readily excite suspicion. There are, however, suggestions in nearly all the above, as well as even more plainly in Romanes, which point toward, and weigh in favor of, what may, perhaps, be the true or best criterion of mentality.

If we define mind by reference to consciousness, what then is consciousness? Mind has the function of producing in the acts of an organism adaptation to environment by direct adjustment. It is the accessory of reaction, the director of action. Our ideas and feelings have reference to motion or its inhibition. The mind is aware of effects and symbolizes causes. The presentation, or representation, or other form of *symbolization* of some environing circumstance, it seems, may be the distinguishing attribute of mentality. For the development of this characteristic power of symbolization, retention or memory is necessary. Discrimination is but a means to more adequate representation. Symbolization, then, is the essence of consciousness.

In view of the function of representation, would it not follow that learning by experience, and the alterableness of action that this implies, furnish the best objective criterion of mentality? There would, in that case, be an intelligent as well as a selective response to environment. There would be *rectification* of action in the fullest sense. Selection, of kinds at least, may be merely mechanical, and it certainly may be merely physiological or unconsciously reflex. But what can sudden alteration in action as a result of experience, without a difference in environment, mean, other than a changed idea of the environment and better knowledge of its effects? Mere physiological habituation would come more gradually.

"Learning by experience" as the criterion of mentality is not new. The suggestion came to the writer from a critical study of Romanes' "Mental Evolution in Animals," ch. I. Though only incidentally, this criterion is actually given in so many words. Since committing to paper his ideas on this subject, the writer has been confirmed in this position by finding that the same criterion has been used explicitly by at least one biologist, while others have had practically the same idea. Dr. Bethe, although his psychology is bad enough, expressly makes

¹ *Lectures on Human and Animal Psychology* (trans.), p. 347.

modification of action through experience the test of mentality.¹ His "Lernprozess," "Erinnerungsprozess," "Lernfähigkeit" are only too rigidly used. After the manner of many biologists, he would exclude mentality till we are sure of its presence. He does not regard the requirement that mind must have evolved considerably before this test is applicable, and, though he explicitly explains the rise of mind by survival value in the face of selection,² he overlooks the difficulty touching reflexes. Rabid Weismannism also affects his views. Another biologist, Prof. Loeb, makes "associatives Gedächtniss" the criterion,³ but in application it seems to be practically identical with learning by experience. He is to be criticised for going to the inferred subjective process instead of stopping at the simple objective fact.

Thus we seem to have a sure test for the presence of consciousness, but it is not necessarily the only one. Another criterion may be preferences unaccountable without reference to an affective element. This seems to be the essence of the choice criterion as M. Binet uses it. Such a test, however, should be employed with great caution, because so much of this unaccountability may be due to our ignorance. But especially preferences different and even opposite with change only in degree of stimulation—instance the reaction of bacteria to oxygen—cannot easily be thought of as merely mechanical, a simple *tropism*. The broader use of the criterion of choice, on the other hand, at least as applied to test the presence of consciousness in particular acts, seems to be valid only so far as implying alterableness and resourcefulness in action, *i. e.*, learning by experience. The reader notices this element in Prof. James as well as in Romanes.

Learning by experience, indeed, is not an all-sufficient and final criterion of whether a being is to be considered mental or non-mental. It is a *sure* test of the *presence* of consciousness, partly just because it requires a considerably evolved consciousness, and this we cannot suppose came into being *de novo*. Lack of mentality is not proved by absence of evidence for learning by experience. Symbolization does not necessarily imply the power of change in symbolization. Those biologists are wrong, and not so scientific as they think, who *deny* consciousness where it is not proved. Incipient stages of consciousness there must be. Yet we cannot know definitely where these beginnings are. And not only is the criterion defective on this side, but careful observation under all possible condi-

¹ Art. in *Pflügers Archiv*, 1898, pp. 19-23 particularly.

² *Ibid.*, 18.

³ *Pflüger's Archiv*, Vol. LIX.

tions is required. It is not the customary and regular movements of micro-organisms, for example, that, according to this criterion, decide their capacity. It is rather the unusual and out of the way in movement, just what the biological student is most likely to miss, and, indeed, to think not worth looking for.

Even the simplest relation of consciousness to action in the particular case, moreover, as is evident, cannot be treated without reference to the relation between consciousness and animal movement in general. It is necessary to consider separately the mental character of the act and the possession of consciousness by the organism which acts. The one does not imply the other. Thus a secondary reflex act is mental in origin, while it is unaccompanied by consciousness. No kind or degree of complexity in reaction, so long as the phenomenon is simply different response to different stimulus, can prove the presence of consciousness; and even a change in response, if it is not sudden or transient, may arise from internal causes that we should call physiological rather than psychological. But it seems impossible satisfactorily to explain the *origin* of certain complex modes of reaction without bringing in consciousness. Its aid, in some other cases, too, we may believe would be an economy, since adaptations merely physiological are hardly capable of everything. There must be limitation somewhere from the nature of the physiological elements. All this means that not much reliance is to be had in negative conclusions drawn from the application of our criterion, whether they refer to a particular act, to an individual, or, as we shall see, to a race.

It is presumable that some adaptations which are strictly mental or conscious in origin have lost their conscious or mental character in the particular individual. Perfect adaptation to environment, through conforming all acts to absolute rules, would perhaps mean, in the simpler organisms, even the entire disappearance of consciousness. Some instincts seem to be sets of actions approximated to this character, and they may best be regarded as racial reflexes, so that an instinctive act need not involve the presence of mind or consciousness in the agent, though mind may have performed its function of adaptation in this matter and consciousness may then have disappeared. Indeed, Cope's position, perhaps not consistently held to, is that mind embraces "the unconscious derivatives of conscious antecedents."¹ Again he says: "Consciousness may be supposed to be necessary to the performance of an act which displays a definite relation to the satisfaction of some need of the animal, but such an act does not necessarily prove that consciousness is

¹ *Loc. cit.*, 900.

necessarily present at the moment of action."¹ And specialization of function, completed education, for him "means unconsciousness, while consciousness is necessary to the beginnings of education and its successive steps up to completion."² The possibility, therefore, is to be taken account of, that in lower organisms all mind may have passed into the reflex stage after adapting the species to its environment. So consciousness may have disappeared from species originally possessing it.

It would be desirable to formulate a definite criterion for the mental origin of organic movements. But general resemblance and connection by fine gradations with acts known to be conscious seem to be the best marks at present available. "Choice" in some sense may be the criterion here, but if so it has yet to be carefully defined and the mode of its application developed. The above quotation from Cope suggests a possibility in this direction. Romanes, also, says that indications of choice are indications of consciousness, but as reflexes have the same appearance, the test is whether the adjustments are invariably the same under the same circumstances of stimulation.³ Thus Romanes himself seems to use the criterion of choice only for what, on one theory of reflexes, would be the remote effects of mentality on action, and in practice, learning by experience as a test for the presence of consciousness behind the particular act. In any case, the criterion at present sought is only to determine whether consciousness is now present in certain forms of life.

In considering protozoa in the light of the foregoing it is important to note that existing species could in nowise represent the first forms of life in respect of mentality. Protozoa are not proto-organisms in the sense of primitive or original forms of life, though they probably resemble these, in external attributes, more closely than does any metazoon. In fact, just in proportion as the *forms* of protozoa and their circumstances of life resemble those of the first forms of life, must the former depart from the latter, supposing the latter to have possessed the germs of consciousness in their psychology.

We are now in possession of what seems to be a definite criterion of mentality. Careful study of the movements of lower animals, with preconceptions such as those here combatted out of the way, should reveal something of their mental condition.

In the study of protozoa from a psychological point of view, although hardly anything can be more interesting and signifi-

¹ *Ibid.*, 901.

² *Ibid.*, 903.

³ *Op. cit.*, 17.

cant, little has been accomplished, both because of inherent difficulty and because of biasing preconceptions. It is not the structure of protozoa, to which the zoölogist is almost exclusively attentive, nor even their regularly performed functions, more likely to be stereotyped in reflexes than to be conscious, that are of most importance from a psychological point of view. Hence the dearth of observations necessary to complete this Study.

M. Binet's little book is a convenient starting point in an examination of the facts bearing on the question before us. He finds plenty of evidence to show that at least some protozoa have something that corresponds to our sensations, especially touch, sight, and taste. He believes, also, that there is the capacity of localizing and even, in one species at least, the perception of position in tri-dimensional space.¹ Instincts he finds, in at least one case, of remarkable development.² These organisms spontaneously control many and complex motions. Preferences are shown for certain objects of food such as seem to involve degrees of pleasantness in gustatory sensations.³ Similar seemingly affective preferences are exhibited by bacteria for certain colors of the spectrum.⁴ Also, in some cases, moderate degrees of intensity of stimulation are sought, while greater intensities are fled from, so that the attraction here could not be merely physical.⁵ On the whole, however, the evidence collected by Binet is in a confused state, and he seems unable to determine what is decided and what not.

Prof. Max Verworn has made a careful study of protozoa with

¹ *Op. cit.*, 53-4, 61, 63-4. J. Soury, in the *Revue philosophique*, Vol. XXXI, attacks Binet's book. He alleges (p. 37) incorrectness of observation in the case of *Diniduum Nasutum* cited. Soury offers no new evidence, and in theory is decidedly bad. He mixes Verworn's theory of consciousness with the belief in a thorough-going chemical physiology, and for the rest his work is characterized by multiplicity of "tropisms" and inconsistencies. In general, as regards the advocacy of tropism, it should be remembered that tropism at its best, *i. e.*, as mechanical attraction, should obey the law of inverse squares, proportional intensity, etc.

² *Ibid.*, p. VI. Questioned by Soury, *loc. cit.*, p. 38.

³ Binet himself cites a different explanation by Maupas, *op. cit.*, 41, 45, 47, 62-3. The writer has hit upon the following, which supports Binet. "Although in two instances the animal [an Acinetan] was observed to capture ciliated Infusorians, its preference is decidedly for the Amoeba, which are abundant in the aquarium referred to." C. C. Nutting, *American Naturalist*, Vol. XXII (1888), p. 14. Another series of observations indirectly significant is that of Metschnikoff, showing preference by phagocytes, especially of dead to living tissue.

⁴ Binet, pp. 33-4. Wundt also says: "The fact that even the protozoa congregate in light of one quality and avoid spots illuminated by that of another must depend on some original sensation character and pleasantness." (*Lectures*, trans., p. 348.)

⁵ Binet, 34, and *cf.* 38.

reference to their psychology, and that without damaging pre-conceptions, though perhaps with the biologist's drawback of thought only for the regular functioning of these simple beings. His peculiar and questionable theory of self-consciousness, however, and his indefensible definition of consciousness according to which it involves self-consciousness,¹ make necessary a reconsideration of his conclusions. He finds that response to stimulus has a mechanical rapidity and sureness, and constancy of form.² He cites one instance of injurious tropism, but it is where the stimuli to that degree are not usual.³ He concludes that stimulated movements are reflex, and spontaneous movements impulsive and automatic, in his own sense of the terms.⁴ "Bewusste psychische Vorgänge in dem Sinne, wie wir sie als Gegensatz zu unbewussten bezeichnen, können bei Protisten noch nicht vorhanden sein," although the germ of consciousness is there,⁵—this in his own sense of conscious. The general drift of his observations would seem to point to the conclusion that the protozoan mind has passed into the reflex stage. Yet one cannot be too cautious in drawing fixed conclusions. No one would now-a-days deny consciousness to rats and mice. Yet a rat or mouse with hind feet cut off will go through the ineffective motions of scratching with them, all his life, without difference in frequency and vigor.⁶

One particularly noteworthy piece of evidence for consciousness in protozoa, moreover, deserves to be cited. Hodge and Aikins have made observations not only valuable for results, but quite as much so for method. Although the observation was made not for psychological purposes, the following is recorded: "We attempted to obviate this difficulty by sterilizing the water supply, and by boiling and covering antiseptically, at the same time giving in the place of their normal food a pure culture of yeast plants. This attempt resulted in an interesting demonstration of the educability of *Vorticellæ*. At first they took this, to them, newly discovered food with great avidity, filling their bodies to distension with food vacuoles of the yeast. In a very few minutes, however, the entire meal was ejected with volcanic energy. Not a single torula was allowed to remain in the body, and for several hours at least—how long the memory lasted was

¹ *Psychophysiologische Protistenstudien*, Jena, 1899, pp. 133-6, 143-5, e.g.

² *Ibid.*, 137.

³ *Ibid.*, 139-40.

⁴ *Ibid.*, 140-41. But cf. Cope's words, *loc. cit.*, 903: "All authorities agree that some of the actions of the Infusoria are in no sense automatic, but display a design as appropriate to the occasion as do those of the higher animals."

⁵ *Ibid.*, 145-6.

⁶ Cf. Romanes, *Darwin and after Darwin*, Vol. II, p. 80-81, ftn.

not determined—the individual could not be induced to repeat the experiment.”¹

It is true that this result stands alone, but the method of observing protozoa seems to be quite as much alone.² Such experimental variation of conditions with patient continuous observation and careful record, not merely of ordinary, but also of extraordinary occurrences, is just what is needed. It is not here the business of the scientific man to find a constant. It is from observations yet to be made that we may hope to learn something of the psychology of protozoa.

In conclusion, it must be admitted that this paper can at most only clear the way for observation that may lead to results. At present materials are inadequate, in respect both of quantity and kind.

¹ “Daily Life of a Protozoan,” *American Journal of Psychology*, Vol. VI, p. 530.

² In a valuable paper, *The Psychology of a Protozoan*, in the *Am. Jr. of Psych.* for July, 1899, H. S. Jennings sets forth certain results obtained from careful study of the Paramecium. He finds it possible to explain by a single simple reflex reaction to stimulus, no matter what or where applied, all the seemingly complex psychical phenomena exhibited by this animal. The response he believes to be in exact analogy to the irritability exhibited by the isolated muscle of a frog. The significance of the character of stimuli, however, deserves emphasis. The fact of an optimal temperature and of reaction not in proportion to the intensity of stimulus cannot, at least, be explained mechanically. If Paramecia, moreover, gather “indifferently about loose fibrous bodies of any sort,” there is a suggestion of something corresponding to the sensation of touch. These facts, it is true, may be called merely physiological; but who can distinguish the merely physiological from the degenerate mental? Does not this suggest the possibility that the physiologist has at least something to learn from psychology as well as from chemistry and physics? It is not the least merit of Dr. Jennings’ paper that he attempts no mechanical explanation of the nature of protozoan activities. He would probably admit that it is only a figurative use of words when he speaks, at the conclusion of the article, of “the machine-like nature of its [the Paramecium’s] activities.” It is always proper to demand of the one who would explain everything mechanically that he *draft* his machine. Until he does this his task is incomplete. Incidentally the importance given to “learns nothing,” in the concluding sentence, may be remarked, as showing what sort of evidence is sought.